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JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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American Welding Society

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AMERICAN WELDING SOCIETY

ESTABLISHED 1919

JOURNAL

VOL. 2. MARCH, 1923. NO. 3

PROGRAM

Annual Meeting

of the

American Welding Society

33 West 39th Street, New York, N. Y.

April 24, 25, 26 and 27, 1923

All Sessions Start Promptly as Scheduled

TUESDAY, APRIL 24, 1923

MORNING

9:30 a. m. to 12. Committee on Training of Operators,
Eleventh Floor J. C. Wright, Chairman

Completion of courses for training of both gas and electric welders.

9:30 a. m. to 12. Resistance Welding Committee,
Tenth Floor Herman Lemp, Chairman

Completion of summaries setting forth the present state of the art. Consideration of a research program and assignment of specific problems to appropriate laboratories and individuals.

AFTERNOON

2:00 p. m. Electric Arc Welding Committee,
Tenth Floor H. M Hobart, Chairman

Reports of progress from sub-committees on standardization of arc welding apparatus, cast iron welding, and applications of arc welding to ship construction. Appointment of sub-committees on welding of non-ferrous metals and manganese steel. Recent developments in the electric arc welding field.

Tuesday, April 24th (Continued)

EVENING

8:00 p. m. **Committee on Welding of Storage Tanks,**
Room 1601 **J. C. Lincoln, Chairman**

Report of progress, revision of existing specifications.

WEDNESDAY, APRIL 25th

MORNING

9:30 a. m. to 12. **Business Session of**
Room 2, 5th Floor **American Welding Society**

PROGRAM

1. President's Report of Year's Activities.
2. Reports from (a) Finance Committee
   (b) Membership Committee
   (c) Meetings and Papers Committee
3. New Developments in Welding Field
   (a) Electric Welding—W. L. Warner
   (b) Gas Welding—G. O. Carter
   (c) Resistance Welding—Hermann Lemp
   (d) Thermit Welding—J. H. Deppeler
4. Report of Teller's Committee on Election of Officers
5. Introduction of New President

AFTERNOON

1:30 p. m. **Inspection Trip to Third Avenue Railway System Shops, 65th Street and Third Avenue**

Through the courtesy of the Third Avenue Railway System an opportunity is offered to members to see the applications of welding in a modern street railway shop. Members will assemble in front of the Third Avenue Railway System Shops at 1:30 p. m. sharp.

EVENING

7.00 p. m. **The Second Annual Dinner of the**
Park Ave. Hotel **American Welding Society**

A real worth while dinner and get-together meeting has been arranged for this year. A good time is promised everyone. Plenty to eat! Good talent! You are cordially invited to attend and bring along your friends. The

dinner will be held in the Park Avenue Hotel, 33rd Street and Park Avenue, starting at 7:00 p. m. sharp. Tickets ($5.00 per person) may be obtained by writing to the Secretary. Be sure to make your reservations early.

THURSDAY, APRIL 26th

MORNING

9:30 a. m. to 12. **American Bureau of Welding**
Tenth Floor

PROGRAM

1. Progress reports by research committee chairmen
2. Election of Officers
3. Discussion of policies
4. Plans of future activities

AFTERNOON

2:00 p. m. **Board of Directors, American Welding Society**
Ninth Floor (Including retiring and new members)

PROGRAM

1. Review of progress during past year
2. Introduction of new President
3. Plans for coming year
4. Appointment of Committees (a) Executive
   (b) Membership
   (c) Finance
   (d) Meetings and Papers
   (e) Revision of By-Laws

2:00 p. m. **Committee on Specifications for Steel**
Tenth Floor **to be Welded, W. J. Beck, Chairman**

Report of progress, plans for future work, including such investigations as are necessary to enable Committee to draw up specifications for steel.

EVENING

8:00 p. m. **Technical Sessions of American Welding Society**
Room 2,
5th Floor

PROGRAM

Welding of Unfired Pressure Vessels, H. L. Whittemore.
Training of Welding Operators, J. C. Wright.

FRIDAY, APRIL 27th

MORNING

9:30 a. m. to 12. **Gas Welding Committee,**
Eleventh Floor **S. W. Miller, Chairman**

Reorganization of Committee, plans for future activities.

AFTERNOON

1:30 p. m. Inspection Trip. Details will be arranged later.

ANNUAL MEETING OF THE AMERICAN WELDING SOCIETY

A program of the annual meeting of the American Welding Society is included in this issue. Attention of the members is particularly called to the following sessions. The business session of the Society will be held Wednesday morning. At this session there will be presented a review of the progress of the years activities of the Society and the new developments in the welding field. This year two inspection trips have been arranged, one on Wednesday afternoon to the shops of the Third Avenue Railway System and the other on Friday afternoon to the plant of some gas apparatus manufacturing company.

The Second Annual Dinner of the Society will be held at the Park Avenue Hotel Wednesday afternoon. A good time is promised everyone who attends.

The technical session which will be held Thursday evening is one of the most important features on the program. The results of the tests made by the Pressure Vessel Committee at the Bureau of Standards will be presented by Professor H. L. Whittemore, Chairman of the Committee. This report is one of the greatest achievements of the Society to date. For the past year or so the research department of the Society, the American Bureau of Welding, has had under way the preparation of a course on the Training of Welding Operators, Mr. J. C. Wright, Director of the Federal Board of Vocational Education, who is Chairman of the Committee will present a review of what the course will include. Those who are expert claim that this course will be the best ever prepared and predict its adoption as standard by all the training schools throughout the world.

Every member of the Society who can possibly do so should plan to attend these sessions.

VICTORIAN OXY-ACETYLENE WELDING ASSOCIATION

We are in receipt of the following information concerning the above association which we think would be of interest to our members. The Victorian Oxy-Acetylene Welding Association is a section of the Victorian Chamber of Commerce.

The Association meets on the first Thursday in each month and different members are appointed to give lectures and addresses on matters appertaining to the Oxy-Acetylene Welding process. The organization started about twelve months ago and at the present time the membership roll consists of about fifty. The section has great promise and it is quite evident that in the near future the Welding Trade will be brought up to a proper standard of efficiency. Arrangements have been made with the Working Men's College, Melbourne, to have a syllabus drawn up and each person desirous of a Certificate of Competency will be called upon to pass a certain test and the examiners appointed will be members of the Oxy-acetylene Welding Section and the Working Men's College.

Membership is open to bona-fide firms using the Oxy-Acetylene Process, provided they make application on the prescribed form, and that a three-fourths majority at a duly constituted meeting of the Association agree to accept such person or persons to membership.

SECTION ACTIVITIES

Philadelphia

A joint meeting of the Philadelphia Section of the Society with the local sections of the A. S. M. E. and the A. I. E. E. was held in the Engineers Club on March 19th. Col. Royal Mattice of the Mattice Engineering Company presented a paper on the "Electric Arc Welding of Large Surfaces." Mr. Mattice's paper was illustrated by slides showing some 70 difficult jobs successfully welded. Brief addresses and discussions were also presented by Messrs. A. S. Kinsey, C. A. McCune and W. Spraragen. About 150 were in attendance.

Chicago

A meeting of the Chicago Section was scheduled for March 2nd in the rooms of the Western Society of Mechanical Engineers. Several discussions on the subject of examination of operators were to be presented.

New York

The March meeting of the Metropolitan Section was held on March 20th in the Engineering Societies Building. Mr. S. W. Miller of the Union Carbide and Carbon Research Laboratories presented a paper on the welding of unfired pressure vessels. This paper included a resume of the work of the Pressure Vessel Committee of the American Bureau of Welding. The investigations undertaken by this Committee were made for the purpose of assisting the Boiler Code Committee of the A. S. M. E. in drawing up proper rules governing the use of welding in the construction of unfired pressure vessels. The other speaker of the evening Mr. C J. Holslag of the Electric Arc Cutting and Welding Company presented a paper on the "Electric Arc Welding of Thin Cast Iron."

Northern New York

The February meeting of the Northern New York Section was held in Union College on February 23rd. Mr. L. C. H. Wagner, Foreman of Tank Welding of the Pittsfield Works of the General Electric Company presented a paper describing applications of welding in the Pittsfield plant. Mr. Wagner described the use of the carbon arc welding on lap welds of 1/16 inch and 3/32 inch material for transformer and conservator tanks. Resistance welding machines have been developed for welding transformer corrigations at the rate of 42 inches per minute using about 12000 amperes. His remarks were illustrated with slides. President C. A. McCune of the Society reported progress made by the different sections, national headquarters and American Bureau of Welding.

The next meeting of the Northern New York Section is scheduled for March 21st at which time Mr. C. J. Holslag is to deliver a paper on "Alternating Current Arc Welding."

San Francisco

The February meeting of the San Francisco Section was held on February 16th. Mr. P. W. Geer presented a paper dealing with tank welding.

The March meeting will be held in the Engineers' Club on March 16th. The speaker of the evening will be Mr. Wm. Aldrich of the Metal and Thermit Corporation who will present a paper on Thermit Welding, together with some demonstrations.

Boston

The March meeting of the Boston Section will be held on March 30th at the plant of the General Welding and Equipment Company, 74 Brookline Avenue, Boston, Mass. Practical demonstrations will be shown on arc welding of sheet steel and cast iron; resistance welding, including butt and flash welding; and gas welding of tool steel dies and cutting cast iron.

PLAN TO ATTEND THE ANNUAL MEETING OF THE SOCIETY

AMERICAN BUREAU OF WELDING ANNUAL REPORT

W. SPRARAGEN, *Secretary.*

Welding is now recognized as one of the greatest aides in the construction and repair of metal structures and parts. Its field of application is almost universal in extent. The matter of fastening two pieces of metal together is one of the fundamental problems of mechanical engineering, since all machines and metal structures are made up merely of so many pieces of metal fastened together. As a general proposition the riveted or bolted point has a tensile strength considerably less than the original piece, whereas the welded point may be made as strong as the original section. Moreover, a welded joint is oil and watertight up to its breaking point, while riveted and chaulked joints leak badly at as low as 25 per cent of their ultimate strength. Considerable economy will also result in time, labor and material in correctly designed welded structures. In the past the wearing of a fraction of a cubic inch of metal from one of the wearing surfaces of a steel part made it necessary to scrap the part with a consequent loss of the labor investment. It was only with the introduction of the autogenous welding processes that it become possible to stop this economic waste. The repair of broken members of a machine has been another important engineering achievement made possible by the electric, gas and thermit processes.

The American Welding Society is organized to provide united and co-operative action in extending the kuowledge of the art of welding and its field of industrial application. The field for further application of welding is enormous, and progress in it is being delayed only by incomplete knowledge and by the confusing and opposing claims of competing interests To secure the extension of the use of welding in the many fields for which it is adopted much investigation is necessary. Through the American Bureau of Welding, which is the Research Department of the American Welding Society and the Division of Engineering, National Research Council on welding research and standardization these investigations are made in a manner to eliminate duplication and waste and secure results at a minimum cost to the industry.

In many instances there is no definite agreement as to the best methods of procedure. Moreover, the recommendations of a number of experts are sometimes actually contradictory even in instances where there is no commercial competition. There is hardly any field of development in our industries today which needs as much real sound fundamental research as welding. The problem is very complex from the metallurgical as from the mechanical standpoint and requires the most expert talent available. It is one thing to obtain a result and quite a different thing to know the reason why the result was obtained. Satisfactory results have been obtained in the welding field in the majority of cases, but when failures have occurred, the reason why was not always known.

Apart from the specific research results, the American Bureau of Welding is beginning to fill a long felt need for an unbiased authority on the many questions arising in connection with this new art. Of these questions some refer to regulatory and safety legislation, some to the training of welders and some to the technique of welding. Answers must be based upon the fundamental scientific facts. Determination of these facts and the reduction of the art to a sound practical and scientific basis is a chief function of the Bureau. Before general confidence in welding can be established, particularly in fields where strength is necessary, its dependability must be satisfactorily demonstrated. The problems of proper welding procedure and training of operators to obtain uniformly sound welds must be solved before such extension in the use of welding can take place. Ordinary evolution of the art would take many years with a resulting loss of millions of dollars to the nation and world.

ACCOMPLISHMENTS TO DATE

The Bureau at present has affiliated with it eleven research committees. These are actively at work and many have published reports which are recognized as authoritative both in this country and abroad. A review of the work of each Committee is given below:

ELECTRIC ARC WELDING—

H. M. Hobart, *Chairman*

The Committee has been active in the stimulation of the industry to conduct research itself thru the exchange of in-

formation at meetings. Several valuable reports have also been prepared and published as follows:

1. Standards for Arc Welding Apparatus, Bulletin No. 3, American Welding Society. The rules include classification, definition of terms, information relative to apparatus to be supplied by the manufacturer and by the prospective purchaser respectively and rating.
2. Summary of the Present State of the Art of Electric Arc Welding of Cast Iron. August-September and November issues of Journal. This report includes the best existing information and methods of procedure in the welding of cast iron and the results of many tests comparing the suitability of various electrodes.
3. Report on the Present State of the Art of the Application of Electric Arc Welding to Shipbuilding to be published shortly in Bulletin form. This is the most comprehensive report ever undertaken on the subject and will comprise a volume in itself.

GAS WELDING

S. W. Miller, *Chairman.*

The attention of the Committee during the past year has been confined to drawing up a summary of the Present State of the Art of Gas Welding of Cast Iron. This report was published in the August-September issue of the Journal.

This Committee has rendered considerable aid to other Committees such as Training of Operators, Welding of Storage Tanks, Welding Wire Specifications and Pressure Vessel Committtee.

RESISTANCE WELDING—

H. Lemp, *Chairman.*

Several reports setting forth the present state of the art have been completed. These reports including those on nomenclature, butt welding and percussive welding were published in the Journal. Tentative Standards for Resistance Welding Transformers which will be equitable to the manufacturer, user and central station man have been compiled and published in the Journal of the Society.

THERMIT WELDING—

J. H. Deppeler, *Chairman.*

Researches which will bring about improvement in quality of thermit welds and reduction of cost, are being carried out by the Metal & Thermit Corporation. This Committee is co-operating with the Committee on Welded Rail Joints in certain investigations.

STANDARD TESTS FOR WELDS—

F. M. Farmer, *Chairman.*

Standardization of procedure in making a test of any kind is obviously necessary before results obtained by different observers can be compared. Difference in detail of procedure in testing welded specimens has caused widely divergent results. Comparisons are frequently impossible, consequently, the usefulness of much of the research work as recorded is restricted and in many casts the statements of results are actually misleading. The Committee has drawn specifications for Standard Tests of Welds, now universally used in this country and which is also receiving the attention of scientists abroad.

WELDING WIRE SPECIFICATIONS

C. A. McCune, *Chairman*

Several years ago, the notion prevailed that almost any fence wire was good enough for welding and although satisfactory results were sometimes obtained, it is now recognized that the most careful consideration must be given to the physical as well as to the chemical characteristics of the welding wire, if good results are to be assured.

During the greater part of the past two years, the Welding Wire Specifications Committee has been actively engaged in collecting data as to the chemical analysis of welding wire used for both gas and electric welding in railroads, shipyards and other places and the service results obtained in the use of such wire. Specifications based upon this information have been drawn and published.

Tests other than of chemical composition for distinguishing between good and bad welding wire, are under consideration. These methods are, (1) heating electricity to fusion, (2), heating by oxy-acetylene to fusion. The theory of these tests is similar to that given for distinguishing between weldable and unweldable qualities in steel as indicated below:

SPECIFICATIONS FOR STEEL TO BE WELDED—

W. J. Beck, *Chairman.*

Experiments have been completed in the plants of four or five companies to investigate several methods which were proposed for distinguishing between suitable and unsuitable material to be welded. The different methods employed in these experiments are:

1. Heating electrically to fusion.
2. Heating by Oxy-Acetylene Torch to fusion.

3. Heating on a vitreous enamel by heating electrically.

In all cases the criterion was that suitable materials are well degasified and fuse quietly, while unsuitable materials are largely not degasified, or only partially and therefore, fuse with gas evolution and more or less effervescence, sparking, bubbling and spattering. The results of the tests show that commercial open-hearth iron was the only material free from gas or gas forming constituents when the metal was heated to a fusion temperature. Data is being compiled which will enable the Committee to determine the working limits for proper specifications of materials.

TRAINING OF OPERATORS—

J. C. Wright, *Chairman.*

A report is in preparation covering the qualifications for welders, fundamentals for welding, analysis of welding jobs and bibliography of welding. The work of this committee is being conducted in co-operation with the Federal Board of Vocational Education of which organization the Chairman is Director. Those who are familiar with the work agree that the two courses now being drawn up for the Training of Gas and Electric Welders will be recognized as authoritative by training schools all over the world.

WELDING OF STORAGE TANKS—

J. C. Lincoln, *Chairman.*

This Committee was organized to meet the requests for information from the Standard Oil Company as to the proper procedure for welding tanks for holding light oils. Considerable difficulty has been experienced in the riveted tank, because such structures in practice do not prove to be "oil tight" for the lighter oils.

The result of this application of Welding promises not only a cheaper, but also a better storage tank and will open up a new and large field to which welding is particularly adapted. Several small tanks have already been built successfully in this way, although the designs were not specially adapted to welding.

Specifications for the electric and oxy-acetylene welding of a tank 40 to 50 feet in diameter and 25 feet high, have been completed. The Standard Oil Company has agreed to construct one of these tanks by welding. The report on electric welding was published in the December issue of the Journal and the one on Gas Welding of Storage Tanks will be published shortly.

WELDED PRESSURE VESSELS—

H. L. Whittemore, *Chairman.*

One of the many difficult problems concerning the Boiler Code Committee of the American Society of Mechanical Engineers in its effort to draw up satisfactory codes governing the construction of unfired pressure vessels is welding. Rules applicable to riveted constructions do not always apply to fabrication by welding.

The problem is seriously complicated because of the meagreness of scientific data upon which to base proper requirements for safety without placing unjust restrictions on the use of welding. Wide differences of opinion prevailed not only amongst the members of the Committee, the insurance companies and inspectors, but also in the industry itself.

A hydrostatic and hammer test was finally proposed for determining whether a vessel was safe for the purpose designed. The American Bureau of Welding, which is the advisory committee on welding research for the American Welding Society and the National Research Council, organized a Pressure Vessel Committee to co-operate with the Boiler Code Committee in determining the adequacy of the test proposed. Eight manufacturers placed at the disposal of the committee some forty tanks and enough funds. These tanks have been tested to destruction by the U. S. Bureau of Standards.

The shells of most of the tanks were 6 feet long and 2 feet in diameter, and made of $\frac{3}{8}$ inch mild steel plate. Both electric and oxy-acetylene welding were used. The hydrostatic and hammer test developed that the welded pressure vessel, according to the regular formula for working pressure, has a factor of safety of about 6.

A remarkable feature of this undertaking is the rapidity of accomplishment. The first meeting of the committee was held in New York on August 17, and a plan outlined. The tanks called for in the program were immediately built by manufacturers distributed widely, (one of them on the Pacific Coast) and shipped to the Bureau of Standards in Washington. Most of the tanks arrived by the first of December. Under the supervision of Dr. H. L. Whittemore, Chief of Section VII-1, Physical Tests of Structural Materials Division, who is also Chairman of the Committee, testing was started December 4 and carried on continuously to January 10. Many

visitors, including members of the Boiler Code Committee, insurance inspectors, tank manufacturers, American Welding Society and National Research Council, have witnessed the tests. A report is being compiled and will soon be published. This program including tanks, testing and incidentals, involved a sum of $15,000.

The manufacturers co-operating in this work are: York Manufacturing Company, Pfaudler Company, Elyria Enameled Products Company, Union Carbide and Carbon Corporation, DeLaVergne Machine Company, Coast Culvert & Flume Company, Brunswick-Kroeschell Company, and Vilter Manufacturing Company.

The data of these tests have enabled the Committee to draw up a number of important conclusions any one of which would have more than justified the total expense involved. This report will be published shortly in bulletin form and in the Journal of the Society. The Manufacturers who participated in this work have expressed themselves as highly pleased with the results. It is a remarkable demonstration of the type of research and investigation that can be carried on by the Bureau on a co-operative basis.

WELDED RAIL JOINTS—

G. K. Burgess, *Chairman.*

American Electric Railway Association and American Welding Society with National Research Council, have united in an authoritative investigation on various types of welded rail joints in commercial use. A Committee on Welded Rail Joints was organized early in 1922, has developed a program, secured financial support, and has experimental work well started.

The solution of the problems involved require co-operation on a large scale. Electric railway companies all over the country are installing thousands of joints every year, in many cases using methods and variations in processes which have been tried elsewhere and found unsatisfactory, or the ultimate effects of which are entirely unknown.

In order to compile a summary of the present state of the art a questionaire was prepared on the four types of joints in commercial use. Answers to the questionaire were correlated and a progress report of 73 pages printed. Typical problems needing further investigation were also included in the report.

The work outlined in the program developed by the Committee will involve a sum of the order of $80,000. Co-operation has been offered from all sides: the rail manufacturers will furnish rail for testing purposes, electric railway companies and joint manufacturers will furnish joints for testing, the U. S. Bureau of Standards, Purdue University and University of Illinois will supply laboratory facilities. Some cash expenditures are necessary, and $24,000 has been placed at the disposal of the committee by the American Electric Railway Association and the following companies:

Boston Elevated Railway.
Chicago Surface Lines.
Cleveland Railway Company.
Community Traction Company.
Connecticut Company
East St. Louis Railway Company.
General Electric Company.
Illinous Traction System.
Indianapolis Street Railway
Louisville Railway Company.
Metropolitan West Side Elevated Railway Company.
The Milwaukee Electric Railway and Light Company.
Pennsylvania-Ohio Electric Company.
Philadelphia Rapid Transit Company.
Public Service Railway Company.
Terre Haute, Indianapolis & Eastern Traction Company.
Third Avenue Railway System, (Dry Dock East Broadway & Battery R. R. Company).
Union Traction Company of Indiana.
United Railways and Electric Company, of Baltimore.
United Railways of St. Louis
Westinghouse Electric & Mfg. Company.
Rail Welding and Bonding Company.
Metal and Thermit Corporation.

To supplement the tensile, drop, repeated impact and conductivity tests, a rotary service testing machine will be built at the Bureau of Standards, in which the joints will undergo wear in one month similar to that which they would receive in ten years of service.

Rails have been shipped by the steel companies to the street railways and manufacturers who are to make up the test joints. Progress has been made in the design of the rotary service testing machine. A number of very interesting factors enter into the design of such a machine, among which may be mentioned the enormous centrifugal force which will be developed, the effect of sprung and unsprung weight, the question of braking, whether flanged or flangless wheels shall be used, whether the track shall be curved uniformly through rails and joints, or whether the joints should be straight and additional curve given to rail on either side, and the manner of constructing and safeguarding the observation pit.

ADMINISTRATIVE WORK

The administrative work of the Bureau has been carried on largely thru the secretarial services supplied by the National Research Council with the guidance of the Director and the Committee Chairmen. Stenographic and office facilities are supplied by the American Welding Society. The Bureau without any funds of its own has been enabled to establish an enviable reputation and has to its credit some remarkable accomplishments. The expansion of the use of welding will be brought about largely thru the efforts of the Bureau and if the industry continues to back this work wholeheartedly, the cost to any one company will be very small.

Some plan should be worked out so that the Bureau will not be financially handicapped in order that it may enlarge its sphere of activities.

Fifteen reports have been completed, and seven others are in preparation. Funds for the investigations of two important committees, Welded Rail Joints and Pressure Vessels have been contributed on a co-operative basis. The Bureau is better known and appreciated.

EMPLOYMENT SERVICE BULLETIN

To meet the demand of its members, the American Welding Society maintains an Employment Service Bulletin. The bulletin is divided into two sections—POSITIONS VACANT and SERVICES AVAILABLE. No charge will be made either to the available engineer, foreman or welder, or to the organization seeking welding talent. The number of opportunities for employment of which the Society has knowledge does not at present equal the number of men whose services are available. The co-operation of members of the Society, industrial establishments and others needing the services of men trained in the various branches of welding is earnestly desired. The location, necessary qualifications for each position and the approximate salary, if possible, should be stated in each case.

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcments will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the Thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the Number Indicated in Each Case and Mailed to Society Headquarters.*

POSITIONS VACANT

V-8 SALESMAN—Opening for a first class salesman to sell gas and apparatus in the Metropolitan District.

PRACTICAL POINTS IN RAILROAD SHOP WELDING*

E. S. ELDRIDGE†

In making a frame weld with an electric arc, the first step is to strip the frame so as to give the welders plenty of room to work. After this has been done, expand the frame from 1/16 inch to ⅛ inch and then cut or burn out the ends of the opening to about a 60 degree "Vee" on both sides of the frame. In case the metal has been burned out, all scales should be very carefully chipped off in order to get a good, clean surface to work upon. Sketches A and B. in Figure 1 illustrate these preparatory stages. After the work has been prepared, the weld is begun at the center, and then continued from edge to edge as shown in sketch C of Fig. 1. By performing the work in this way, the same contraction is secured on the last layer as on the first. After the weld has been brought up flush with the sides of the frame, the outer edges are

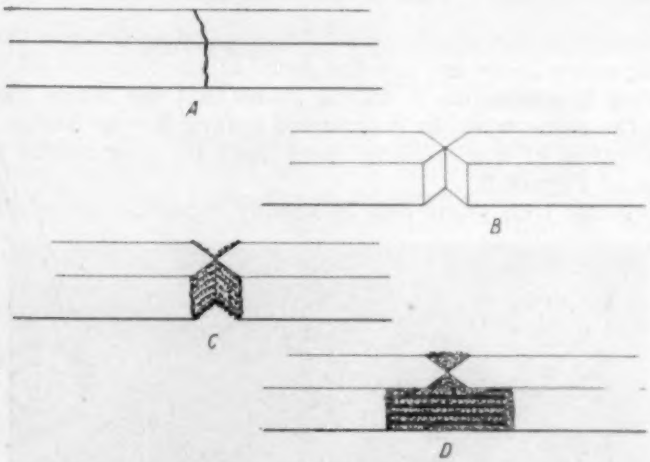


Figure 1. Various Steps in Welding a Broken Frame by the Electric Arc.

reinforced with ⅝ inch or ¾ inch round bars of mild steel, 8 inches long and the spaces between the bars are filled in to give the necessary strength. A drawing of such a completed weld is shown in sketch D of Figure 1 and a photograph of such a job is shown in Figures 3 and 4.

For acetylene welding the engine frame is prepared in the same way as for electric welding except that the expansion is made ⅜ inch, which is a little larger than that required when the electric

*Presented before the January 1923 Meeting of the New York Section of the A. W. S.

†Welding Foreman, D. L. & W. R. R. Shops, Kingsland, N. J.

arc is used. The actual welding is usually performed by two operators, one on each side of the break. The frame is brought up to a yellow heat in the vicinity of the weld before the rod is applied. The weld is begun at the bottom of the "Vee" where a matted state is first produced. Each succeeding layer of material reinforces the

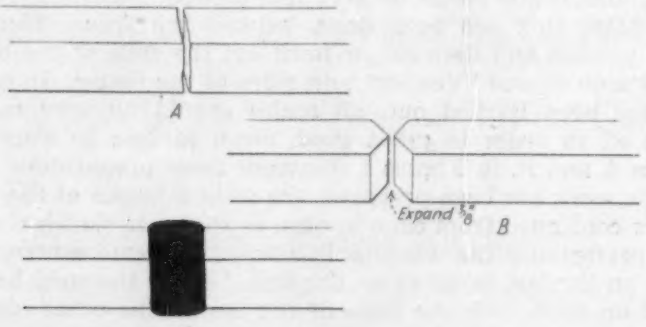


Figure 2. Stages in Frame Welding By Gas Torch.

previous layer about 25 per cent. After the weld is made the jacks and wedges are taken out and the metal allowed to cool off. When the cooling is completed, it will be found that the frame has come back to the same position it occupied before it was broken. The various stages of gas welding work may be seen in the several sketches of Figure 2.

Broken cast iron gears can be readily repaired by substituting

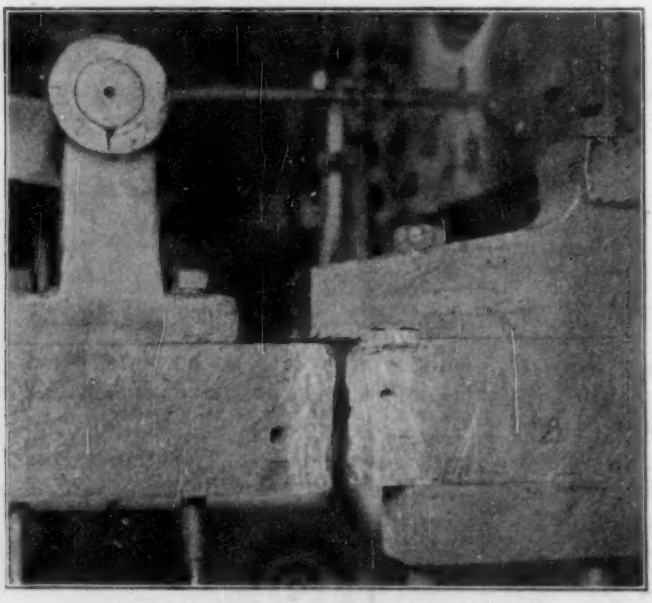


Figure 3. Broken Frame Prepared for Electric Welding.

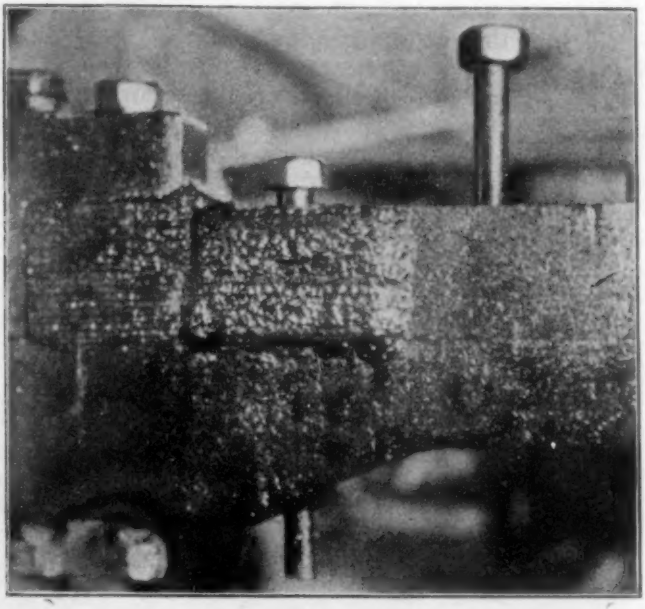


Figure 4. Electrically Welded Frame.

Tobin bronze for the missing metal parts. So far it has always been practical to use Tobin bronze in connection with gas welding. In repairing broken teeth the metal is chipped out to a depth of about 1/16 inch below the root of the tooth. Heat is then applied until the Tobin bronze flows freely. This temperature is slightly below the melting point of the cast iron. The Tobin bronze is spaded over the surface to obtain a tinning effect which is easily secured when the metal is at the right temperature. If the bronze

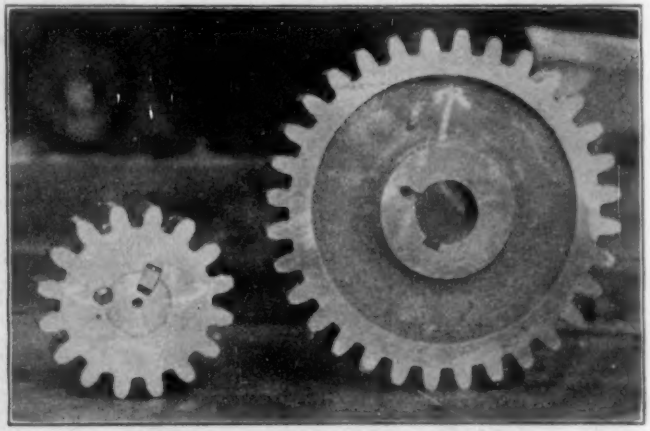


Figure 5. Gears Repaired with Tobin Bronze.

is too hot, it will not take hold or bite into the cast iron and if it is too cold, it will roll off in a ball. When the temperature is correct, however, the Tobin bronze will flow like water. After the gears have been built up in this way, the bronze teeth will stand more strain than the cast iron teeth. There have been instances where the cast iron teeth have broken out of a brazed gear and the bronze teeth, while bent over, still held as firmly to the body of the gear as when first put on. A sample of gear repairing may be seen in Figure 5.

In building up cast iron or brass cams or cam straps to take up side play, the Tobin bronze is put on the same as for gears. By brazing the cams and strap in this way about 15 hours of machine work is saved on each cam and cam strap and at the same

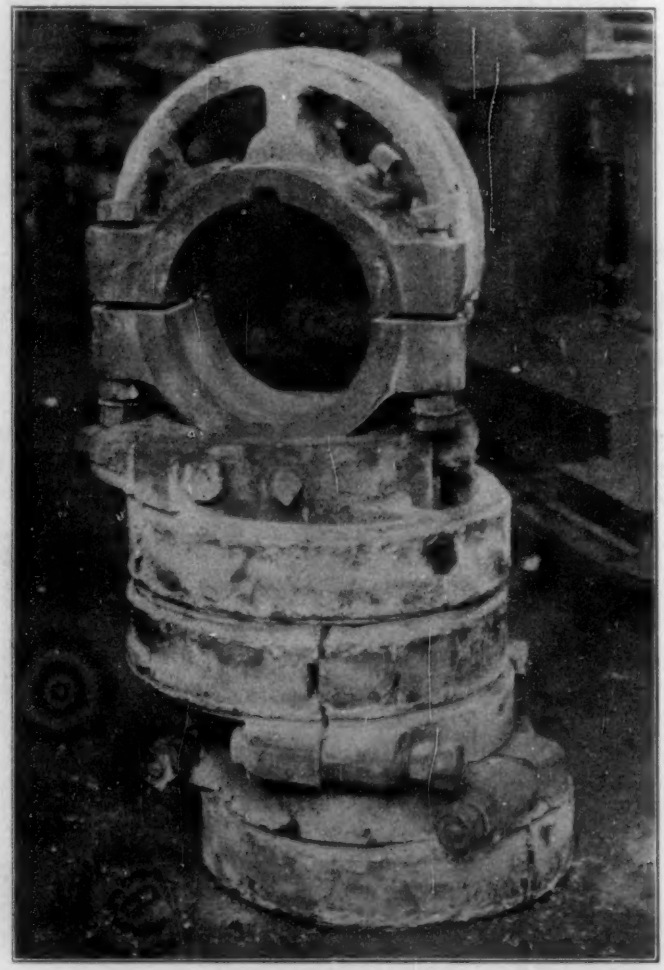


Figure 6. Pile of Eccentric Cams Repaired With Tobin Bronze.

time a set is secured which is as good as new. A pile of eccentric cams is shown in Figure 6. In the brazing of piston heads, it

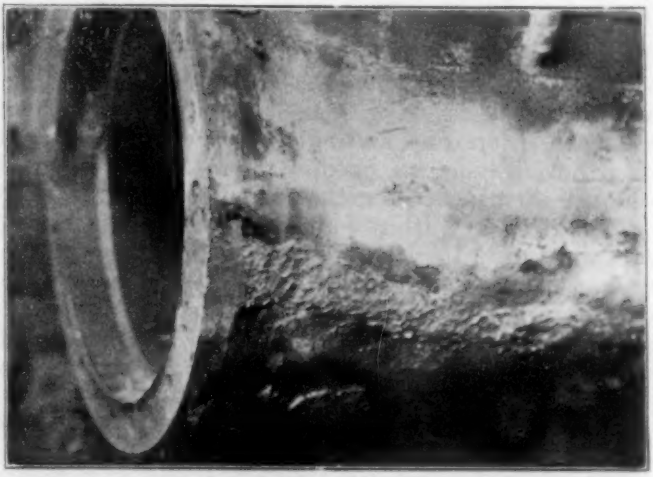


Figure 7. Broken Cylinder Repaired with Tobin Bronze.

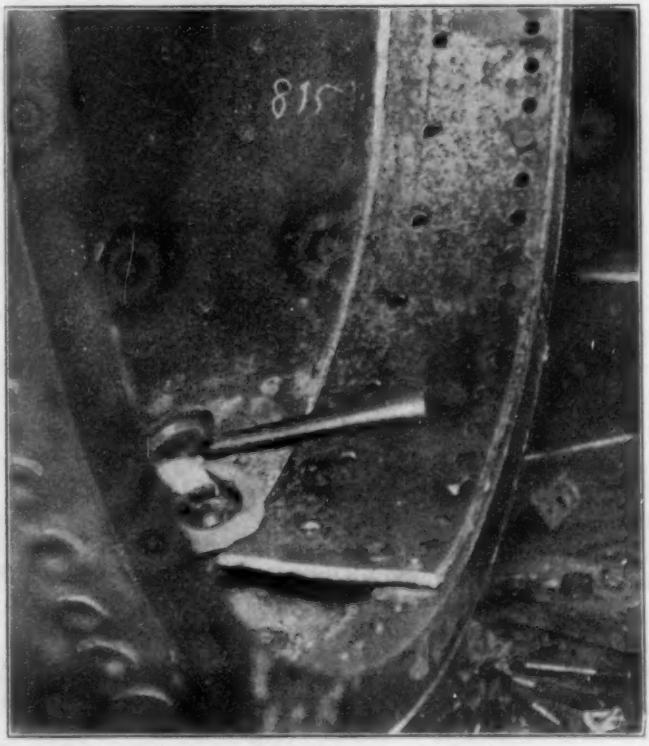


Figure 8. Preparations for a Fire Box Patch.

is first necessary to turn them down about 1/32 of an inch in order to get below the glazed metal. After this has been done, they can be built up to any size desired. In the process of brazing piston heads, the bronze and cast iron are worked together with the result that the mixture of metal will wear longer and will not cut the walls of the cylinder.

In welding firebox sheets with the electric arc both the old and new sheets are chipped to an angle of 45 degrees and the sheet butted together, leaving an opening from 1/16 inch to 1/8 inch. The sheets are then tacked together about every 6 inches in order to hold them in place, after which the welding is begun. The first layer is placed in the opening and the remainder of the "Vee" filled up and reinforced, always using the cross welding. In welding patches in fireboxes, always cut round corners so as to avoid locked up stresses. The patch should also be dished about 1/4 inch. Tack the patch at intervals of 6 inches except at the

Figure 9. Two Driving Wheel Spokes Repaired by the Electric Arc.

bottom. The work should alternate, first welding about 6 inches on one end and then 6 inches on the other until the top of the patch is reached. The top seam is then welded, the bottom being left until last. In welding the bottom seam, first tack it as before. By welding the bottom seam last, the heat will travel up through the patch and when contraction takes place the patch will straighten out and the heat of the bottom weld will soften the patch and take away all of the strain. Preparation for a firebox patch is shown in Figure 8.

Another interesting application of electric arc welding is found in the welding of spokes to engine wheel (See Fig. 9). In this work the spokes are "V'd" out to about 45° and all scale chipped off one

inch back of the weld. The tire is then heated with the tire heater until the broken spokes open up about 1/8 inch, after which the weld is made in the usual manner, reinforced about 1/8 inch to 1/4 inch all the way around the spoke so that when the wheel is cooled off it will come back to where it was in the first place. Trying to weld spokes without heating the wheel will result in a flat spot in the rim and cause a break either the weld or in the spokes at another place.

GRAPHITE WELDING ELECTRODES

S. L. WALWORTH

The use of graphite electrodes for welding and cutting where the former carbon arc was employed is becoming increasingly popular as the merits of the graphite arc are more widely known. Even at present the graphite arc practice is endorsed or recommended among the largest welding machine manufacturers and among the largest users of the carbon arc process for welding and cutting purposes such as rivet burning, rough cutting and cutting or burning off of gates and risers on castings, quick filling of holes and many kinds of welding.

Pure homogeneous graphite electrodes can only be made by treating in the electric furnace amorphous carbon articles which have previously been made into the desired form. The temperature to which they are subjected is such that the elements other than carbon are volatilized—driven off as vapors—leaving behind the carbon in the graphite state, the article retaining its original form. In this manner rods, plates, tubes and other shapes can be formed from a mixture of finely-ground carbon with pitch or tar while in the plastic state, then baked to carbonize the pitch bond, and later subjected to the requisite electric furnace treatment to convert the entire mass—bond and aggregate—into graphite. The result is a solid piece of practically pure graphite, possessing all the properties of high-electrical conductivity, resistance to oxidation, increased density, and extreme workability, which distinguish graphite from non-graphitic carbon.

Such an electrode is not to be confused with other so-called "graphite" electrodes in which graphite is employed in whole or in part as the aggregate, with some form of hydrocarbon bond, nor with those carbon articles which have been only superficially or partly graphitized.

This in a word is the process of manufacture of graphite electrodes. A few of the main advantages to the user with attendant reasons may also be of interest.

The figures given below define some of the properties of

*Acheson Graphite Company.

graphite electrodes and will permit direct comparison with other materials:

	Graphite Electrodes	Non-Graphitic Carbon	Copper	Aluminum	Iron
Specific Resistance Ohms per in. cube	.000320	.00124	.00000065	.00000120	.00000380
Specific Resistance Ohms per cm. cube	.000813	.00315	.00000165	.0000003048	.0000009652
Comparative Sec. Area for same V. drop	1.0	3.8	.00203	.00375	.0119
Weight, lbs. per cu. inch	.0574	.0564	.320	.090	.280
Tensile Strength, lbs. per square inch.	*800 to 1,000	*1,000 to 1,500	20,000 to 30,000	24,000 to 30,000	30,000 to 50,000
Temp. of oxidation in air	660°C	370°C			

*Lengthwise of electrode. Figures for Tensile Strength, crosswise, are 500 to 600 lbs., and 600 to 900 lbs., respectively.

Although the tensile strength of graphite electrodes is lower than that of the non-graphite carbon, it is a fact, often observed in practical work, that they are not nearly so brittle, and the breakage in handling and in operation is so appreciably lessened by the use of graphite that this becomes a factor in determining the choice of electrode for a given case.

Breakage and cracking due to sudden change in temperature are virtually unkown where graphite electrodes are employed. In the process of their manufacture the entire piece is carried to a temperature higher than that required for any other electrothermic process and far beyond the maximum attained in baking non-graphitic carbon electrodes. The method employed in cooling is such as to anneal the graphitized electrode and render it proof against those heat shocks, which so often result in the destruction of other electrodes with loss, not only of electrode material but of time and efficiency. The better thermal conductivity of the graphite resulting in more prompt equalizing of temperatures within the electrode mass and securing more uniform expansion and contraction may explain this.

Owing to the slower vaporization of graphite by the arc much less carbon is carried into the weld when using graphite electrodes. This produces a softer weld than is possible with amorphous carbon electrodes and the weld more nearly approaches the composition and hardness of the parent metal and is much easier to machine.

The arc is much steadier with the graphite electrodes and the high temperature of oxidation of graphite makes the life of the graphite product from two to three times as long as an amorphous carbon of the same diameter.

From the above table it may be seen that graphitized electrodes have four times the electrical conductivity of carbon electrodes of

the same cross section, consequently the heating of the electrode caused by resistance is negligible.

Being cooler while in use they are much easier for the operator to handle and the excessive spauling off and cracking which always accompanies hot carbon electrodes is entirely done away with.

At the same time this increased electrical conductivity allows much higher current densities to be carried by the graphite electrodes without excessive heating. The following is a table of current densities used in good practice with graphite electrodes.

Size Graphite Welding Electrode	Current per Electrode	Current Density Amps. per Sq. In.
1/4"	130 to 250	2650 to 5000
3/8"	185 to 270	1870 to 2700
1/2"	260 to 440	1320 to 2200
5/8"	340 to 560	1100 to 1800
3/4"	410 to 660	930 to 1500
7/8"	500 to 850	830 to 1400
1"	600 to 1000	760 to 1250

The maximum current densities allowable will vary according to the length of time the arc is drawn and also according to conditions under which the welder is working.

It will be of interest to note that the cost of graphitized electrodes is approximately 75% more than the plain carbons, and this increased first cost must of course be offset by the possible advantages above set forth to prove their use is economical. The present wide use of graphite welding electrodes answers this.

I look to see in the future a considerable development in the art of carbon arc welding and cutting, and I believe the use of grapite electrodes in this art is going to play an important part in this development.

EXTRACTS FROM A REPORT ON ARC WELDING (K JELLBERG'S SYSTEM)

M. HARMIISHI†

Experiments conducted at the Nagasaki Works, of Messrs. Mitsubishi Zosen Kaisha Limited.

In arc welding, oxides and nitrides of iron are formed in the arc, and are dissolved into molten metal, remaining therein as a solid solution as the metal is cooled rapidly. When the metal is annealed at the forging temperature, these impurities melt away from the state of solid solution, and from tissues along the surfaces of the iron crystals, with the result that they weaken the cohesion of

†Mitsubishi Goshi Kaisha

the crystals, and cracks sometimes occur along such segregated impurities.

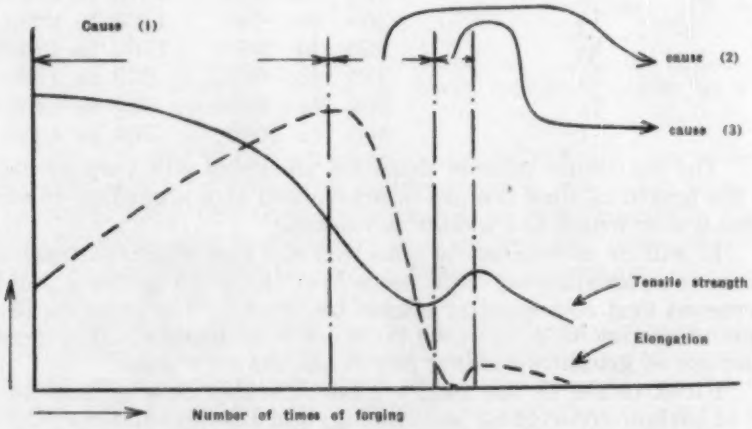
Tensile strength and elongation of deposited metal are greatly affected by forging, the effects being due to the following three facts:

Cause 1. Change of iron from the martensitic to ferrite structure, due to rapid cooling.

Cause 2. Weaking of the cohesion of the crystals due to the segregation of impurities, as stated above.

Cause 3. Gradual decrease of nitrogen content.

The effects of forging on tensile strength and elongation are diagramatically shown below:



In view of the above facts, it became quite clear that in order to make deposited metal malleable, some method of welding to minimize the nitrogen and oxygen contents was necessary, and this we succeeded in accomplishing, and such impurities were reduced considerably as is seen in the following table:

	Ordinary deposited Metal	Deposited metal after Improvement	Ordinary Lowmoor Iron
Carbon	0.09 %	0.10 %	0.10 %
Phosphorus	0.053%	0.053%	0.08 %
Sulphur	0.044%	0.044%	0.011%
Manganese	0.28 %	0.15 %	0.070%
Copper	0.064%	0.083%	0.073%
Silicon	0.022%	0.016%	0.019%
Oxygen	0.123%	0.074%	
Nitrogen	0.078%	0.033%	0.0056%

Furthermore, as a means of ascertaining the quantity of blowholes and slag content in the metal welded in accordance with

the above improved method, measurements were taken of the specific gravity and electric resistance of the metal, the results of which are tabulated below:

	Specific gravity	Electric resistance in Ohms
Ordinary deposited metal	7.50	554
Deposited metal after improvement.....	7.69	480
Lowmoor Iron.....	7.76	442

RESULTS OF SMITH WORK ON IMPROVED DEPOSITED METAL AND PHYSICAL TESTING

These samples of improved welded metal were treated as follows:

Mark	Weight of Hammer Used, 9 lbs.	Tensile Strength	Elongation
HBO- 1	Original M. Steel (3 in. x 3/8 in.)	20.7	
HBO- 2	" " " "	20.7	
HB- 1	Without reheating and without hammering	20.5	
HB- 2	" " " " "	20.9	
HB- 3	" " " " "	21.5	

	Temperature Applied	First Application		Second Application		Third Application		Length Increased After Hammering	Long Tons per square inch	%
		Heating Minutes	Number of Hammerings	Heating Minutes	Number of Hammerings	Heating Minutes	Number of Hammerings			
H. B. 4	800°C	30m.	23	20m.	23	20m.	23	3/4"	No Crack After Bending	
H. B. 5	"	"	"	"	"	"	"	"	"	"
H. B. 6	"	"	"	"	"	"	"	"	21.6	22.7
H. B. 7	"	"	"	"	"	"	"	7/8"	21.5	19.5
H. B. 8	900°C	"	"	"	"	"	"	1"	Small Crack at End of Bend	
H. B. 9	"	"	"	"	"	"	"	1"	"	"
H. B 10	"	"	"	"	"	"	"	3/4"	22 1	20.3
H. B. 11	"	"	"	"	"	"	"	7/8"	21.7	23.8
H. B. 12	1000°C	"	"	"	"	"	"	7/8"	22.2	22.3
H. B. 13	"	"	"	"	"	"	"	"	Small Crack at End of Bend	
H. B. 14	"	"	"	"	"	"	"	3/4"	21.1	23.8
H. B. 15	"	"	"	"	"	"	"	1 1/4"	Small Crack at End of Bend	

Note Samples—H. B. 4, H. B. 5, H. B. 8, H. B. 9, H. B. 13, and H. B. 15, were given bent tests, the others tensle tests.

SELECTING WELDERS*

S. W. MILLER†

It is rather difficult to lay down any definite plan for selecting a welder from a number of applicants, because frequently the different applicants have different personalities and require different treatment, but the general method I followed was about as follows:

Usually the first question asked was, "What experience have you had?" Answers to this varied widely and it was usually found that the more capable men were the more modest in their claims. The welder who claims to have been welding for fifteen years is becoming less frequent. The general subject of oxy-acetylene welding was referred to and the applicant asked what the principles of the apparatus were, what equipment he had used and what difficulties he had had with it. Inquiry was always made as to the largest and smallest jobs that had been worked on and what success or difficulty had been experienced.

Careful inquiry was always made as to the reasons for leaving previous jobs and it was not felt creditable to the applicant if the fault always lay with the employer or foreman. Also, when a man had worked in many places, it was felt that this was rather a discredit than otherwise although, of course, this is not always true.

The man's preference for the kind of metal to be welded was always sounded out, and his reasons for this preference. If he claimed to be an all round welder, he was closely questioned on the welding of steel. If he claimed to be particularly good at any one metal, the inquiries were directed along that line, and if his experience had been rather narrow, the inquiries were confined within that sphere.

His physical characteristics, eyesight, general neatness and appearance were closely observed, and such matters as courtesy, politeness, clearness of his replies to definite questions, and his ability to explain himself were noted. His age, approximate height, and weight, family and other personal matters were also considered. Finally he was asked to show his ability in practical work.

It so happened that we had almost every well known make of torch on hand, although they were not all in use in the shop, so that it was but seldom that a man could not be tested with the equipment he had said he used. He was given the tanks, regulators, hose, torch and specimens of metal and instructed to start at the beginning and make every move until the weld was completed. He was allowed to use his own judgment as to the size of flame and its adjustment, but was closely watched during the work.

In many cases it was found that his general knowledge of welding matters was sufficient to warrant employing him, even though

*To be presented at March Meeting, Chicago Section, A. W. S.
†Union Carbide and Carbon Research Laboratories—formerly Proprietor Rochester Welding Works.

he was not proficient in some of the details. If a man is intelligent and knows how to handle a torch, he can be taught how to weld, but a shop is usually too busy to spend time instructing one who claims to know much about welding, but who really does not, although there is no objection, and in fact some advantage in having a certain proportion of the employees entirely ignorant of welding, because they can be trained by degrees into the best practice. Such men, properly selected, usually become valuable welders.

There was a clear understanding that there would be a probation period of two weeks, during which the man could familiarize himself with shop routine and with the general methods in use. If, at the end of that time he did not appear to be developing, he was questioned to find out what the difficulty was. If it seemed to be mere negligence or laziness, his services were usually dispensed with. In the past I found that, in spite of considerable care in the selection of welders, it took a long time, and cost a considerable amount of money in spoiled work, loss of time, lack of speed, etc., to make a welder that could be relied upon when given a job to carry it through with but little supervision and make a success of it. One of the most necessary things in a welder is ingenuity or resourcefulness, and it is almost impossible to determine these qualities except by a trial of some length.

A METHOD OF PEVENTING MAGNETIC OXIDE FORMATION WITHIN A WELDED TRANSFORMER TANK

FRANKLIN S. SMITH*

The gas filled high voltage transformer was developed primarily as a component part of a sterilizer for the destruction of insect life in milled cereals.

In this type of transformer the cooling and insulation are affected by a gaseous dielectric consisting of 60% helium, 37% nitrogen and 3% oxygen under a total pressure of about 15 atmospheres. It is of course obvious that the tank and its fittings must hold this gaseous dielectric indefinitely. A few of these transformers have been in service about three years and show no perceptible loss in pressure.

Figure 1 is a view of a completed transformer. All welds were effected by oxy-acetylene, and, excepting the end shell weld near base of tank, were made in the usual manner and then thoroughly sandblasted inside the tank to remove magnetic oxide.

*Products Protection Corporation.

The transformer coils are of bare copper wire the turns of which are spaced only, by solid dielectric. These windings, of course, are supported and fixed by solid dielectric, but in such a manner that the bare wire is exposed. It is obvious that any free conducting matter, such as magnetic oxide, could do considerable damage.

The solid dielectric is bakelized paper, and is undamaged by

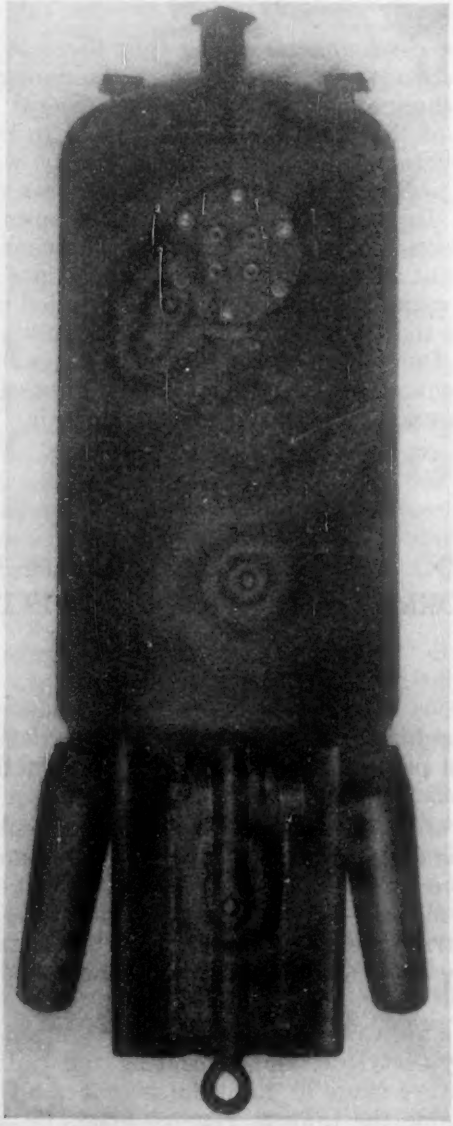


Figure 1. Gas Insulated and Cooled Transformer. 15KVA—23KV/230-115

a continuous temperature of 110°C, or by 300°C for a duration on the order of ten minutes.

Figure 2 shows open end of tank with transformer positioned ready for insertion of end shell. The solid dielectric nearest this end of tank is at such distance, and in such position that radiation from end shell weld does not damage this insulation.

Heat by conduction is cared for by small water stream as illustrated in Figure 3.

After the end shell has been inserted the tank is turned up side down. It is then rapidly purged with nitrogen. The transformer

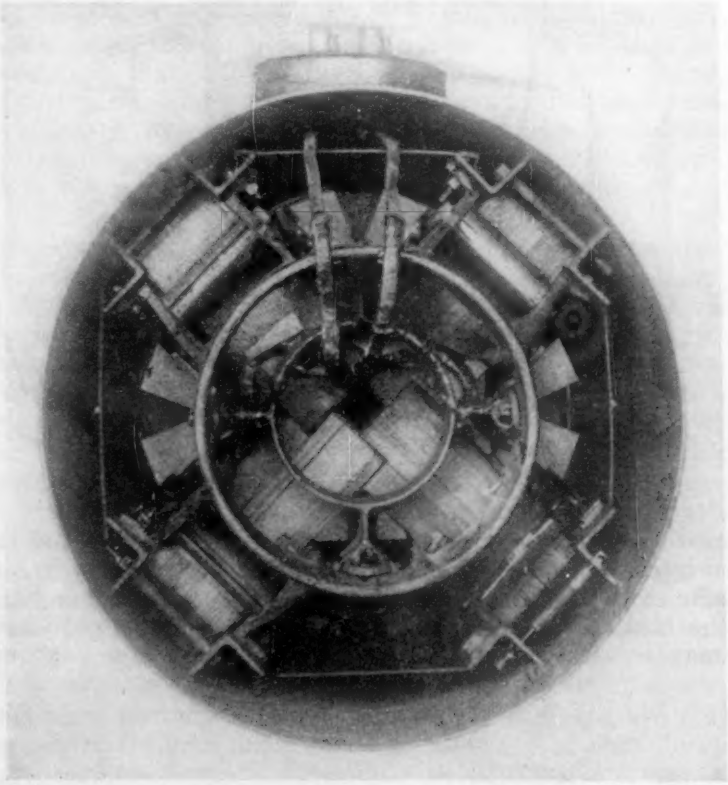


Figure 2. View Through Open End of Casing. (Complete assembly except end shell).

tank illustrated is 17 inches diameter x 53 inches over all, its effective volume about 6 cubic feet. The quantity of nitrogen to sufficiently purge a tank is about fifteen times its effective volume. The rate of nitrogen flow is controlled by the pressure regulator at the gas bottle.

After the purge, the nitrogen is kept flowing at about the rate of ½ cubic foot per minute per foot of circumference of end shell, assuming a "push fit" between end shell and tank wall.

The end of tank wall is then heated by the torch and hammered over and against the end shell. When this hammering has been completed the flow of nitrogen is reduced to about 10% its former value.

An atmosphere of nitrogen is then maintained within the tank during the time of affecting the end shell weld. As the weld progresses the rate of nitrogen flow is decreased and stopped entirely just before the weld is closed.

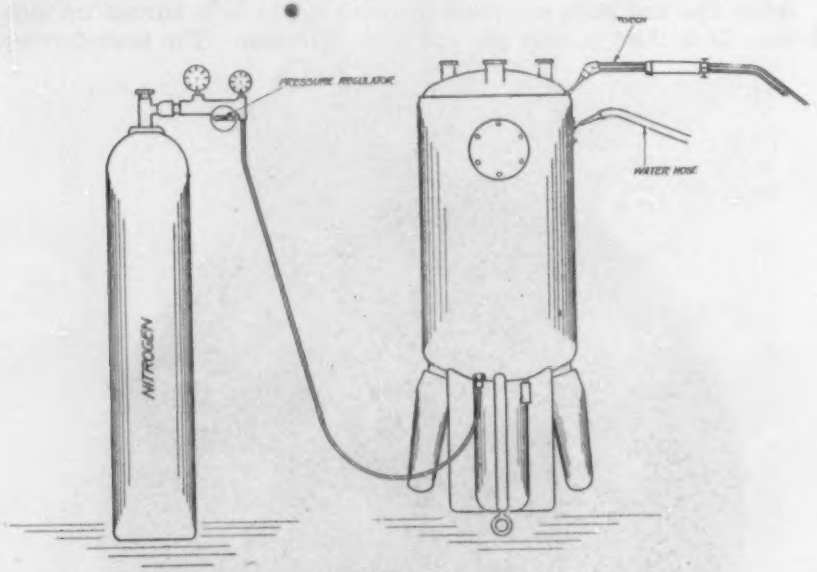


Figure 3.

Transformer tanks welded in the foregoing manner and subsequently cut open for examination were found entirely free of magnetic oxide except a trace in the crack between the end shell and the tank wall. This oxide was quite adherent and caused no damage.

MODERNIZED PIPE CUTTING

T. C. FETHERSTON

Large users of pipe, particularly in the oil and gas industries, are employing the oxy-acetylene cutting blowpipe extensively for making new and used pipe into equipment and devices for field and plant use. Manufacturers of equipment built entirely of pipe, such as manifolds, coils, heat exchanger units and absorbers for use in these industries, also employ the cutting process extensively in preparing pipe for fabrication.

Stock lengths of new pipe and odd lengths of reclaimed (used) pipe enter into much of this work. There is a great deal of irregular cutting that cannot be done as well by any other means as with a cutting blowpipe. In cutting odd-shaped holes, sections and angles necessary in welding the specially designed pipe equipment, the cutting blowpipe is manipulated by the more experienced operators with the same dexterity with which other operators cut flat metal.

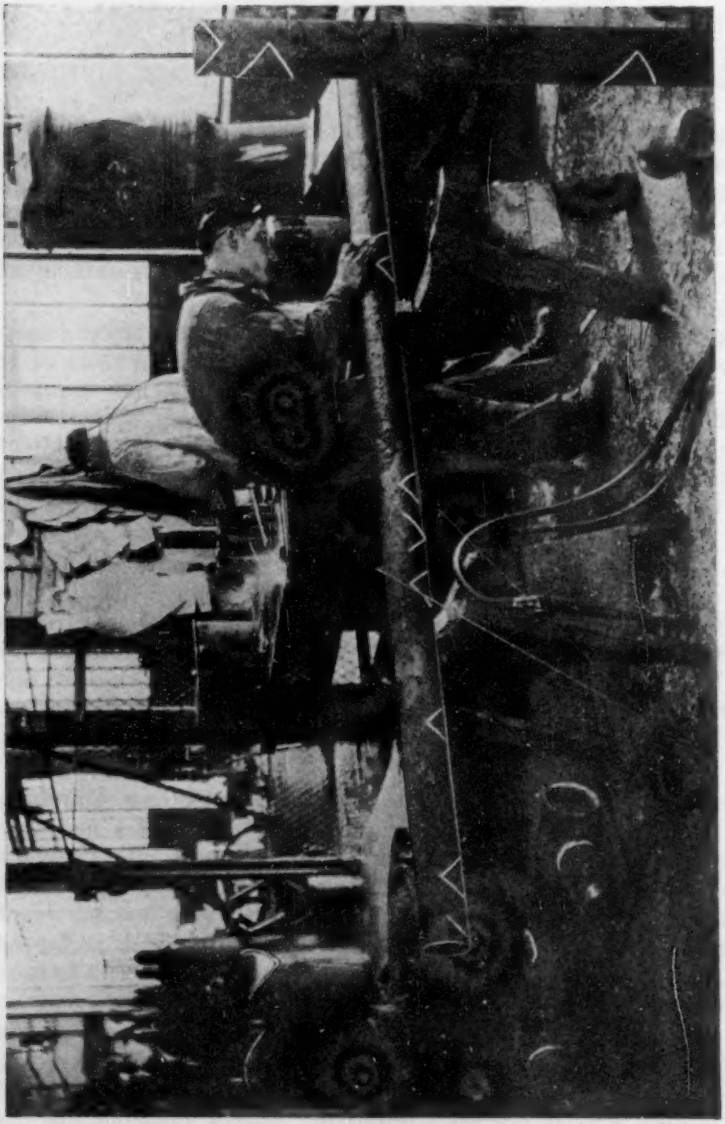
In the shops of two of the foremost natural gas companies in the Ohio field, all pipe equipment and special fittings are built by oxy-acetylene cutting and welding. Most of the equipment is made from used pipe. In the production of specialties, practically all of which are now made up of second-hand pipe, purchase of new pipe castings or fittings except for the most unusual purposes, has been obviated by the oxy-acetylene operator's ability to cut salvaged pipe to form.

The accompanying illustration shows a section in one company's shop. The operator in the foreground is mapping out a manifold by chalking the holes which he will cut in a piece of pipe to which laterals will be welded . It is the practice in this shop to use patterns cut from heavy brown paper on most of the work. Each operator has a set of patterns. The use of patterns aids in laying out the holes and cutting to size, shape, and at different angles, and it usually results in cleaner cuts and better fitting joints.

Undamaged portions of partly defective scrap pipe are cut to size as needed for such metal pieces as baffle plates, ends for closing pipe, patches, supports for coils, nipples, circular straps, and loops. In this way oxy-acetylene cutting makes possible the use of small sections of badly pitted or otherwise unfit pipe.

Saddles or pipe straps used to stop leaks are made by cutting strips from scrap steel sheets. A hole is burned in one end for an eye, and a bolt is welded to the other end. The operator in the background in the illustration is welding bolts on such straps. A quantity of the straps can be seen on the floor at the left.

Although most of the cutting is done in the central welding shops of these companies, a cutting station is usually carried in the field



Operator Chalking a Manifold Preparatory to Cutting Openings and Welding in Laterals. The Blowpipe is Used for Both Operations.

by each crew, and is used for cutting odd lengths, finishing off rough places, and meeting other emergency requirements.

A recent development is the application of cast iron pipe cutting. A contractor in Chicago while laying a 16 inch cast iron water line through a lagoon needed a 6 foot length to tie-in the two ends of the line. To cut the required length by the old methods would have taken several hours. The foreman sent a standard length to an oxy-acetylene job shop in the vicinity. The pipe was cut as de-

sired and returned to the job in about one hour.

Oil producing and pipe line companies are adopting the oxy-acetylene process for cutting pipe in production much as was earlier done by the natural gas companies. In the fabrication of new and used pipe one of the largest oil pipe line companies in the mid-continent field uses the welding process for many purposes. Nearly every purpose, however, requires a certain amount of cutting to prepare the pipe for welding.

A gas company in Texas recently put in 8 miles of welded 6 inch and 8 inch second-hand pipe. The threaded ends were cut off. The pipe was in random lengths which ranged from 4 foot pieces to standard 20 foot lengths.

Another gas company in the East has installed nothing but welded lines since 1914. When unable to purchase the pipe required with plain ends, the company buys threaded pipe and cuts off the threads as the pipe is unloaded and before it is sent into the field.

MANGANESE STEEL CUTTING

Z. T. DAVIS

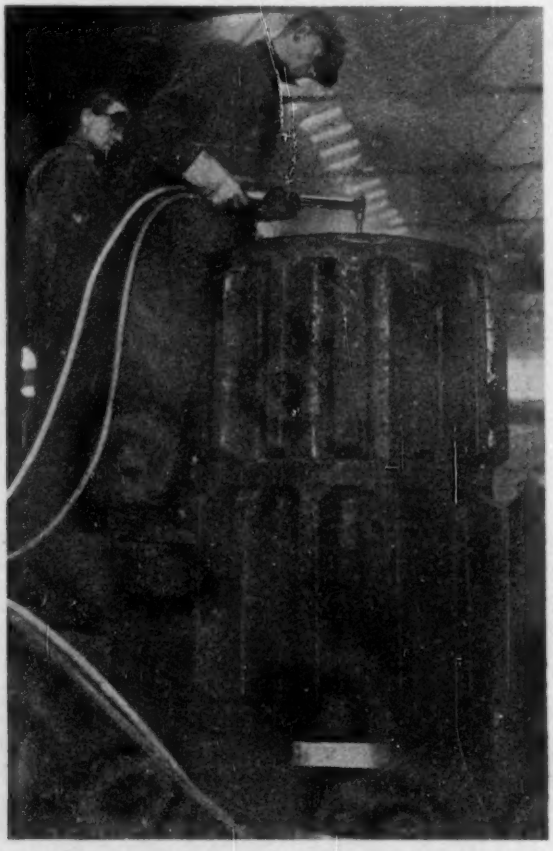
A hollow shaft on which a helical pinion (4 feet 6 inches in length) was shrunk had broken while in use and the shaft and pinion were returned to the maker to be replaced. This particular maker guarantees such equipment for a definite period of service.

The manganese steel gear shell was in good condition and could be used again if the remaining part of the manganese steel shaft could be removed without damaging the pinion.

The first step in reclaiming the pinion was to cut off the shaft flush with the ends of the pinion. This was done with the oxy-acetylene blowpipe and the operators next tried to slot the hollow shaft so that it could be contracted and forced out of the shell. They attempted to do this cutting with the pinion lying on its side. The cuts dragged, the operators being unable to force out the slag. This was due to the horizontal position of the pinion and the difficulty of operating in the limited space with the pinion in this position. Moreover, smoke and heat poured out of both ends of the shaft preventing the operators from carrying the cut very far into the hollow. After several fruitless attempts they decided that the shaft could not be cut.

The management of the foundry, mindful of the value of the gear shell, was unwilling to give up so readily and carried the problem to the representative of an oxy-acetylene apparatus manufacturer who arranged for a service operator to handle the job.

The service operator succeeded in completing the cut in one hour. He had the pinion set in a vertical position resting on two "I"-beams supported in turn on two wooden horses, which provided a clearance of about three feet between the pinion and the foundry floor. The work was set up without obstructing the space directly below the hollow center of the shaft. A scaffold was then raised so the operator could work from above as shown in the accompanying illustration. The service cutter took up the work where the foundry operators had left off, starting with the shallow slot which had been carried a few inches into the opening. He used the same



Operator Cutting Groove in Hollow Shaft Shrunk on Pinion. Note the Slag Issuing from Pinion at Lower end.

type of blowpipe and the same size of internal nozzle that had been used in the first effort to make the cut, but he used considerably higher oxygen pressure than the foundry people had used.

After carrying out the cut about half way through the thickness and about half the length of the section of shaft he once more

began at the top, this time carrying the cut to within about ¼ inch of the pinion. The pinion was then inverted and the cutting was carried out in the same manner from the other end so the slots would meet in the center. These cuts were made with the blowpipe held in the position shown in the photograph. During this time the operator lowered the blowpipe into the shaft only a few times and then only to melt the slag that had cooled and stuck to the sides.

With only ¼ inch of metal remaining to be cut throughout the section of shaft the pinion was placed on the foundry floor—the position in which the foundry operators had placed it for their several cutting attempts. The conditions now, however, were quite different. With only ¼ of an inch thickness of metal to cut the slag problem was not a serious one. Moreover, the kerf was wide and the operator could watch his work and avoid burning the pinion, something that would have been almost impossible on a cut of metal several inches thick even under more favorable conditions than those prevailing here. The operator, of course, changed the internal nozzle on the blowpipe to the size suited to cutting through ¼ inch thickness of metal and lowered the oxygen pressure to what it should be for such work. As before he worked from one end to the center and then from the opposite end to the center, thus completing the slot through the shaft.

A stream of cold water was then played into the shaft to contract it and it was forced out of the shell by means of hydraulic pressure. This operation was somewhat aided, of course, by the fact that the shell itself was slightly expanded due to the heat of cutting. The inside surface of the pinion was not harmed in any way by the oxy-acetylene cutting. It was smooth and required no reworking before being shrunk on a new shaft.

1922 JOURNAL
BOUND VOLUME

A few copies of the bound volume of the Journal for the year 1922 are still left. It makes a neat appearing book and contains many valuable reports and papers.

Copies may be obtained at $5.00 each from the Secretary.

INVESTIGATION OF THE EFFECT OF TORCH CUTTING FORGED STEEL.

J. R. DAWSON†

The oxy-acetylene cutting torch is considered almost indispensable by many manufacturers of steel and steel products. Its use has increased with great rapidity and is retarded only by a lack of knowledge of the many advantages it offers. Of recent years the practice of torch cutting forgings to finished shape has become quite general, for by this means a great deal of time and expense are saved. Because of the large field for this work and the importance of the quality factor, a study has been made to ascertain the effects which result from use of process and how best to control them. Included is an explanation of correct procedure for carrying on this work and a discussion of the economies that are obtained by oxy-acetylene cutting.

Material Examined.

Two 4 inch x 6 inch forged specimens, that had been cut on the 4 inch side by a torch cutting apparatus, were selected for examination. The cut was regular and quite smooth. The chemical analysis of the steel was:

C.	Mn.	Si.	S.	P.
0.37	0.50	0.14	0.027	0.018%

The average Brinell hardness was as follows:

(a) Of steel not effected by cutting 143
(b) Of torch-cut face, ground just enough to remove the oxide coating 207

Examination for Cracks.

This investigation has consisted largely of macroscopic and microscopic examinations of the steel as affected by various conditions and treatments. The specimens were first examined by a hand magnifying glass on all faces and no cracks could be observed. Next the torch-cut face of one specimen was ground and polished just enough to remove the scale left by the operation. This surface was thoroughly examined in the same manner and no cracks were found. Throughout the investigation careful watch of both macroscopic and microscopic specimens has failed to reveal any cracking.

Depth of Heat Effect:

A second specimen was next ground and polished and etched on planes perpendicular to the cut as follows:

(a) At the top of specimen where the cutting flame entered the metal.
(b) Lengthwise of the cut.
(c) Bottom of cut where the flame emerged.

†Union Carbide and Carbon Research Laboratories.

Fig. 1. Top of Beginning of Cut.

The darkness area shows the depth of metal that has been affected by the heating incident to the torch cut. The maximum depth of this area is 1/8 inch.

Note: Macrographs are all magnificid 1½ diameters. 10 per cent solution of ammonia persulphate used for etching.

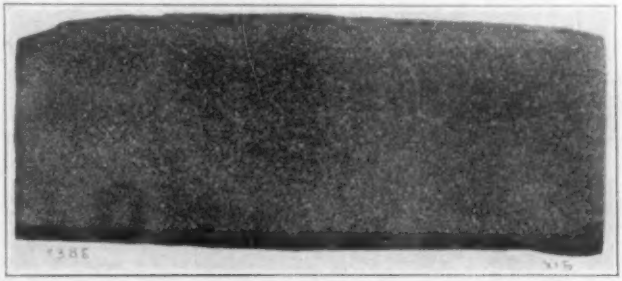


Fig. 2. Lengthwise of the Cut.

The top of the cut is at the left. It is shown that the depth of effect is quite uniform from the top to within 1/8 inch of the bottom, where it extends more deeply into the metal. The excellent character of the cut is shown by the smooth, straight line of the cut edge.

Structural Changes Resulting From Cutting:

The four micrographs shown in Figures 4 to 7 are included to show the structures that are produced by torch cutting a steel of this character. All photomicrographs at 100 diameters. Etching with 5% solution of picric acid in alcohol.

Normalizing of Torch Cut Forging:

In this paper normalizing is used as meaning heating to sufficiently high temperatures, 1400°F to 1650°F for example, to produce a refinement of the grain structure.

Low temperature annealing is heating to the neighborhood of 1250°F to relieve strains but not high enough to break up and refine the grain structure.

Sections that included both the areas affected by the heat of cutting and the unaffected areas were normalized and examined. (See Figs. 8 to 10).

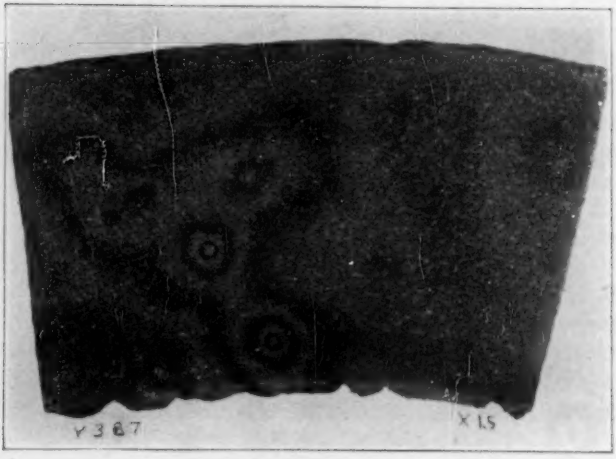


Fig. 3. Bottom of Cut.

Relatively light colored metal in irregular form is shown at the cut edge. The oxygen jet has melted and partially decarbonized some of the cut out steel which has run down to the bottom of the kerf and adhered to the forging. The heat contained in these melted drops has been sufficient to weld them to the forging and by conduction to cause the heat penetrattion to be deeper at this point.

The maximum penetration as measured on the original photograph is slightly less than 3/8 inch and divided by 1.5 the magnification used, gives less than 1/4 inch as the maximum actual depth of heat penetration.

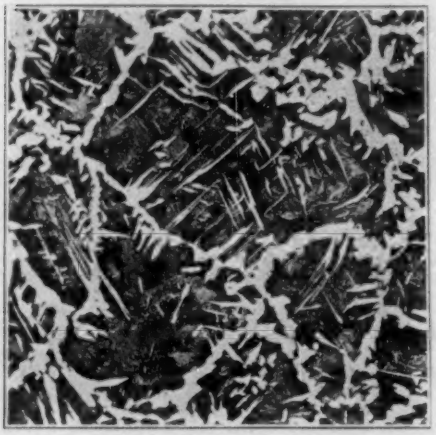


Figure 4. X 100

This micrograph, Fig. 5, shows the junction between the extreme point of heat effect and the unaffected original material. In the upper part of the micrograph is the original structure, which is characterized by large, irregular grains of pearlite surrounded by thick ferrite envelopes and containing needle-like areas of ferrite within and extending into these grains. In the lower part of the photograph the temperature of the metal has risen high enough to begin to break up the original structure by the absorbtion of the constitutents, one into another. In this portion the carbon containing constituent has been cooled more rapidly than was originally the case and is in a sorbitic rather than pearlitic condition.

Torch Cutting Red Hot Steel:

A specimen of this steel was placed in a furnace and heated to about 1450°F, then removed and cut by the torch while at this temperature, and then cooled in the air. (See Figs. 11 to 13).

Returning Piece to Furnace After Torch Cutting While Red Hot.

A specimen of the same steel was cut while red hot and returned to the furnace, brought to 1450°F for ½ hour and furnace cooled. (See Figs. 14 to 16).

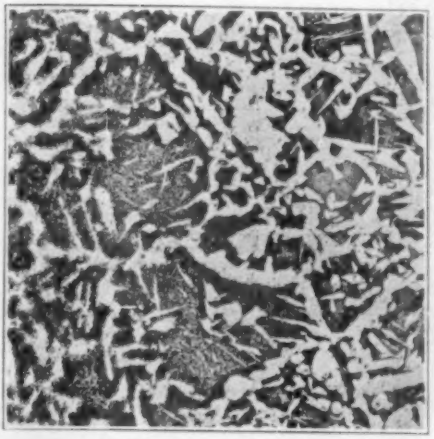


Figure 5 X 100

Figure 4 shows the original structure of the forging. Except for the heat-affected area the structure of the entire forging is similar to that illustrated by this micrograph. The heat treatment that produces a structure of this type may be satisfactory and suitable for most forgings, yet there is no question but that more desirable structures should be obtained.

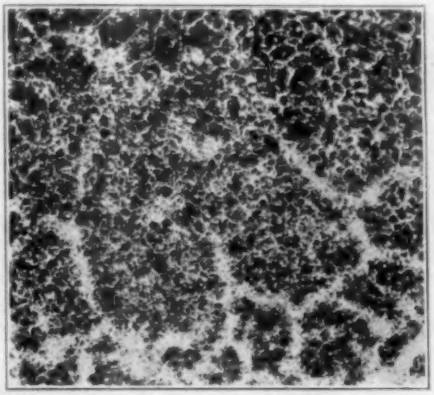


Figure 6 X100

Figure 6, immediately adjacent to the previous micrograph. As the cut edge is approached the original grain structure is more and more nearly eliminated until finally at the bottom of the photograph it has entirely disappeared and in its place are small grains of sorbitic pearlite surrounded by ferrite envelopes.

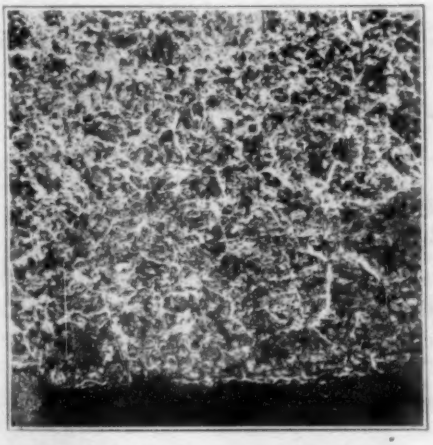


Figure 7. X 100

Figure 7, taken adjacent to Figure 6. As the cut edge which is shown here is approached, the heating has caused the grains to be somewhat larger than in the previous micrograph where the temperature was not quite so high. However, they are by no means so coarse as in the unaffected steel. The material shown in the preceding three micrographs is somewhat harder than when in its original condition. This hardening is brought about by the chilling action of the adjacent cold metal.

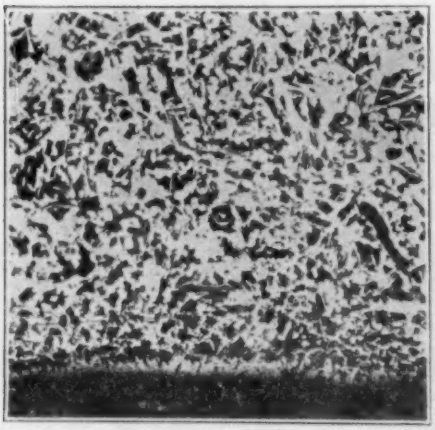


Figure 8 X 100

Figure 8 is of the same location as was shown in Figure 7, which was of the torch cut edge. The piece has been normalized by heating to 1450°F. holding at that temperature ½ hour and cooling in the furnace. The same effect would be obtained by cooling a heavy section in the air. The structure of the edge and the interior of the specimen were practically the same. All traces of the torch effect have been removed and the coarse structure of the forging has at the same time been much improved.

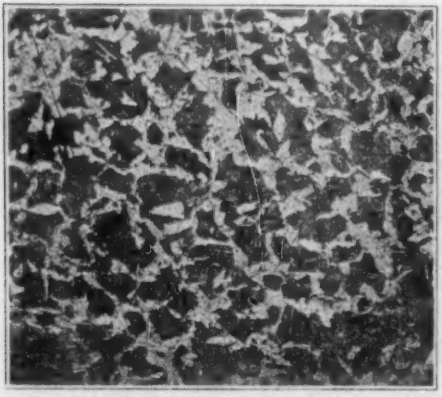


Figure 9. X 100

Figure 9 shows the structure of torch cut edge after normalizing at 1600°F for one hour and followed by slow cooling. The grains are larger than were obtained with the 1450°F for ½ hour treatment, which indicates that the shorter time, lower temperature normalizing is to be preferred.

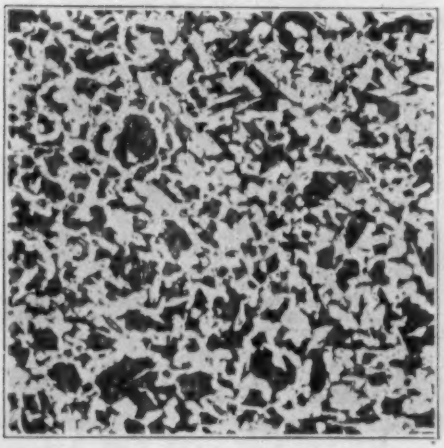


Figure 10. X 100

Figure 10 is of the interior of same specimen as shown in Figure 9. The appearance of the two is practically the same, showing that the structure is refined throughout the material.

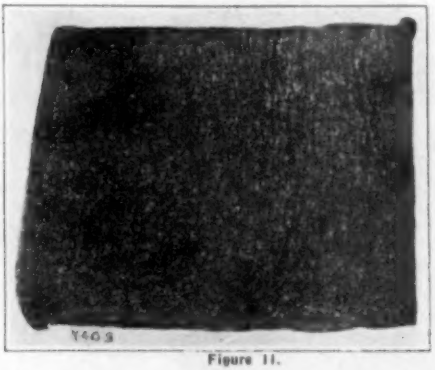


Figure 11.

In the above micrograph (Figure 11) is shown the etched section of the steel cut while hot. The cut was made along the left hand edge where it can be observed that the grains are coarser than in the remainder of the specimen. It should also be observed that no line of heat effect is evident, as was the case in the specimen as cut cold that was first examined.

Discussion of Methods for Torch Cutting of Forgings:

Our own experience, as well as that of various other investigators whom we have queried, has brought out the fact that cracking does sometimes result from the operation of torch cutting steel. The consensus of opinion is that cracking does not occur except in defective or dirty steel. One company that does a great deal of torch cutting finds that cracking takes place only in the billet from the top of the ingot, in which part the majority of the non-metallic inclusions are contained. On this account they do not cut the steel from the top billet and do cut the steel from the remainder of the ingot without difficulty.

Examination of the torch-cut specimens submitted for this investigation has shown that no cracks were present in them. The probability that strains are set up by the process is indicated by the difference in hardness of the original forging and the face that had been cut. It seems reasonable to believe, however, that a forging of good quality steel should have sufficient strength and elasticity to prevent the starting of cracks.

The macrographs used in connection with this paper have shown that the maximum depth of heat effect is $\frac{1}{4}''$ and the machining off. of $\frac{3}{8}''$ of metal would certainly remove all the affected material.

Some strains are pobably set up by the torch cutting but it is the writer's belief that where the steel is of good quality, free from segregation, non-metallic inclusions, and other objectionable irregularities, and forging has been carried out so as to leave good metallographic structure, any strains set up will not be severe enough to cause cracking to result. Steel relatively low in carbon, such as was examined in this investigation, would have sufficient ductility to withstand any strains set up by cutting, and except in

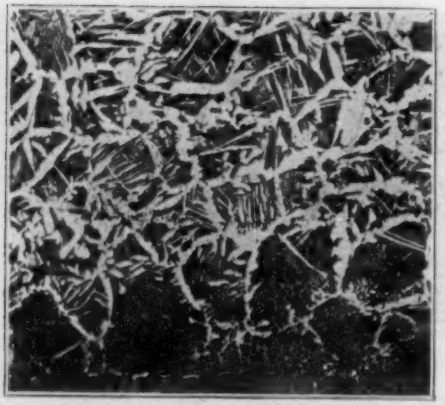


Figure 12. X 100

X 1.5

The structure shown in this micrograph, Figure 12, of the edge cut red hot, is similar to that of the original untreated steel, but is more desirable because it is less coarse.

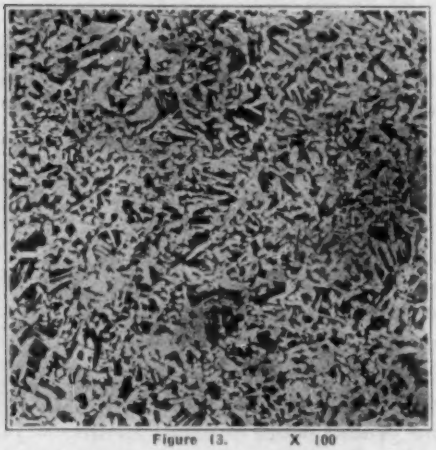


Figure 13. X 100

Figure 13 is of the interior of the same specimen as was shown in Figure 12, which is of steel cut while red hot and cooled in the air. The heating previous to cutting has refined the structure nicely.

cases where defective material is cut, confidence should be had that no cracks will result from the operation.

It is reasonable to assume that the present method of manufacture of important steel forgings, as carried out in the various shops, is a safe method. Examination of forgings has shown that a very appreciable percentage of the possible efficiency of the material is frequently lost by manufacturing methods that are incorrect. The particular forging examined during this investigation was of a very coarse, undesirable structure due to finishing at too high a temperature.

It seems to be entirely evident that where forgings are manufactured by torch cutting, and then machining off the affected steel or employing proper heat treatment, there results a product which is as satisfactory as one produced by machining alone.

The micrographs that are a part of this paper have shown

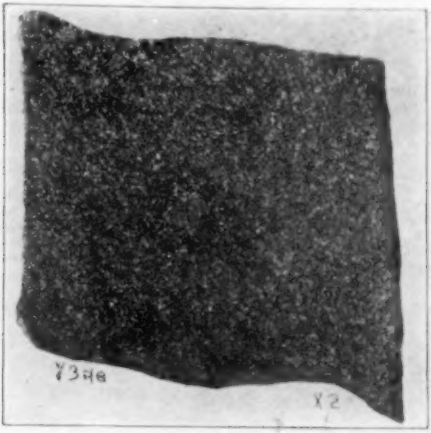


Figure 14. This macrograph, is of the section treated as described above. The left hand edge shows the structure next the torch cut. It may be observed that the machostructure is quite uniform throughout the specimen.

conclusively that normalizing after torch cutting removes entirely the effects produced in the steel structure.

Not only are these heat effects removed but the condition of the entire forging is much improved by heating to about 1450°F to 1500°F for ½ hour, followed by slow cooling. By slow cooling is meant in the furnace for small pieces or in the open air for heavy sections. In heat treating a large forging sufficient time will of course be required to bring the entire section to a uniform temperature, and on this account it should be held at the desired temperature for a longer time than was necessary for the laboratory treatment shown here.

There is no question but that low temperature annealing at from 1250°F to 1300°F will relieve all strains due to the heating during torch cutting, but the condition of the entire forging is so much improved by higher temperature normalizing that it is to be preferred.

The experiments carried out in connection with this investigation have shown quite clearly that it is preferable to cut the forging while hot. A curve plotted for the amount of thermal expansion vs. temperature of steel follows quite closely the so-called cooling curve. Except at the critical point where there is a change in the curve, the expansion is proportional to the increase of temperature. When a hot forging is cut the temperatures at the point being cut and in the remainder of the forging are not very different and severe strains are not set up. In this connection it is probable that preheating the forging before cutting would save enough oxygen to offset the cost of the preheating, besides materially improving the product.

It would be more economical to cut the steel while still hot from the forging operation than to allow it to cool and then reheat.

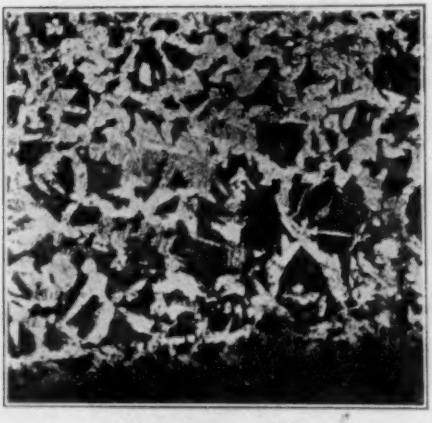


Figure 15. X 100

Figure 15 is of the edge next to the torch cut in the specimen that was reheated to 1450°F for ½ hour after cutting while red hot. This structure is good although somewhat coarser than in the interior away from the cut as is shown in the following micrograph.

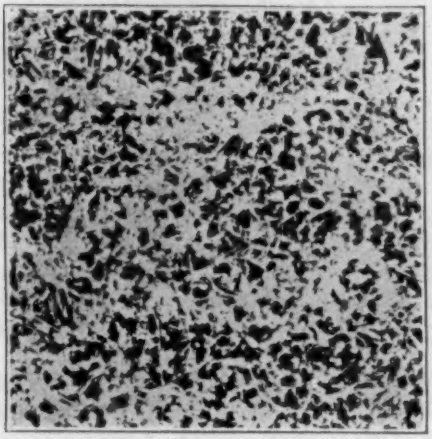


Figure 16. X 100

Figure 16 shows the interior of section returned to the furnace after cutting.

This would be satisfactory and would save the expense of an extra furnace heating.

A still further improvement would result if the forging is returned once more to the furnace after cutting. This heating should not be expensive, as the material could be returned to the furnace immediately after completeing the cut, when it would contain a large amount of heat and therefore not require a great deal of time or expense to raise to 1450°F. By this treatment the original coarse forging structure would be completely refined and any slight strains remaining in the steel would be relieved. The writer does not feel that the last treatment is always necessary but would be worth while when the best possible product is desired.

Special precautions should be observed where forgings are required to withstand severe stresses in service and where safety of

life and property depends upon the quality of the product. For such purposes:

All forgings should be normalized after cutting.

A forging containing more than 0.45% carbon should be preheated before cutting.

These precautions of course are not required for low carbon steels or for parts that are not severely strained in use.

The saving of time and money that attends the use of the oxy-acetylene cutting torch is unquestioned. No machine shop can afford to dispense with this useful tool. The manufacture of a locomotive side rod offers an example of the saving in time that is obtained. The machining of a locomotive side rod forging requires seven days. The same operations is performed by the oxy-acetylene cutting torch in a few hours, followed by less than one day's finish machining. The usual saving of expense in work of this nature is about 70%. This is for the operation itself, but the potential saving is still greater for the torch cutting outfit reduces the number of heavy machines that are required and increases the capacity of those already on hand. The cutting torch then means that a greater output can be obtained with a smaller investment of capital.

Summary of Information Obtained During the Investigation:

No cracks were present in the two specimens of torch-cut forgings that were submitted for examination.

The maximum depth of heat effect was less than $\frac{1}{4}$".

All heating effects are removed by normalizing.

Strains that may have been set up in the metal are removed by low temperature annealing, but normalizing is to be preferred because of resulting improvement in structure.

As has been shown it is not essential to have the forging hot for cutting, but whenever convenient this method is more desirable.

Improvement results from normalizing after cutting, whether the forging was preheated or not.

The writer recommends that the oxy-acetylene operator cut the forging while hot, return it to the furnace and heat it to 1450°F for $\frac{1}{2}$ hour (or until uniformly heated throughout) and then allow it to cool slowly.

WELDING THIN SECTIONS IN CAST IRON*

C. J. HOLSLAG†

Improvements in welding cast iron of thin section have quite kept pace with other developments of the industry generally. Electric arc welding can now be applied to work that must remain in place, and cannot be preheated. Such jobs include the welding of cracked automobile water jackets, crank cases, heating boiler sections, and garage and factory heating boilers. Very small boilers and the like may easily be repaired by careful work, but the time and trouble necessarily spent is often uneconomical, unless it is impossible to replace the broken section by a new one.

However, on the same count that small, easily replacable sections are welded at an expense not quite proportionate to their size, the welding of large units, as cracked waterjackets and the like, is obviously desirable, both in regard to expense and efficiency. A large water jacket may be repaired without disassembling the motor, or undergoing the danger of warping the cylinders, and a crank case may be welded in place without even melting the babbitt in the bearings. The process also shows up to great advantage in the welding of a furnace section cracked through application of sudden heat, because it not only does away with dismantling, but obviates the danger of the freezing of the plumbing system while new sections are being installed.

The fundamental principle that must be borne in mind when welding cast iron of thin section, is that the two cast iron edges must be joined by means of a band of deposited steel. The steel must be applied to both edges equally, and in small amounts at a time, care being taken to make the weld as tight as possible before proceeding to another section. This, however, is not always possible in the first operation. If not, a filler (which will be described below) may be applied from either the outside or the inside. This filler may act to prevent seepage, while the weld supplies both the strength and a major amount of the tightness.

In some cases, all that is required is the joining and contracting effect of a few well-placed lines of steel beading, made by welding rows of cross-beads at right angles to, and across the crack. Often the contractile effect of these bands or links is so great as to be sufficient to draw the two edges of the crack together until they are in perfect contact. In this case, a filler is unnecessary, as the repaired metal is practically as solid a piece as it was before the crack appeared. The application of this method is illustrated in Figure 1. In applying these bead links, it is well to choose their location with a view to securing the most efficient results. It will be noted that the first cross-beads are run each

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Presented at March 1922 Meeting, New York Section A. W. S. Paper taken from book to be published by the McGraw-Hill Book Company.

at a little distance from each end of the crack, after which the rest are run in the indicated order.

If the crack is now found to be tight, nothing further need nor should be done. If additional strength and tightness, however, is found to be desirable, a "V" may be chipped out along the line of the crack, taking care not to make it deep enough to disturb the alignment made with the crosswise bands, or with exterior

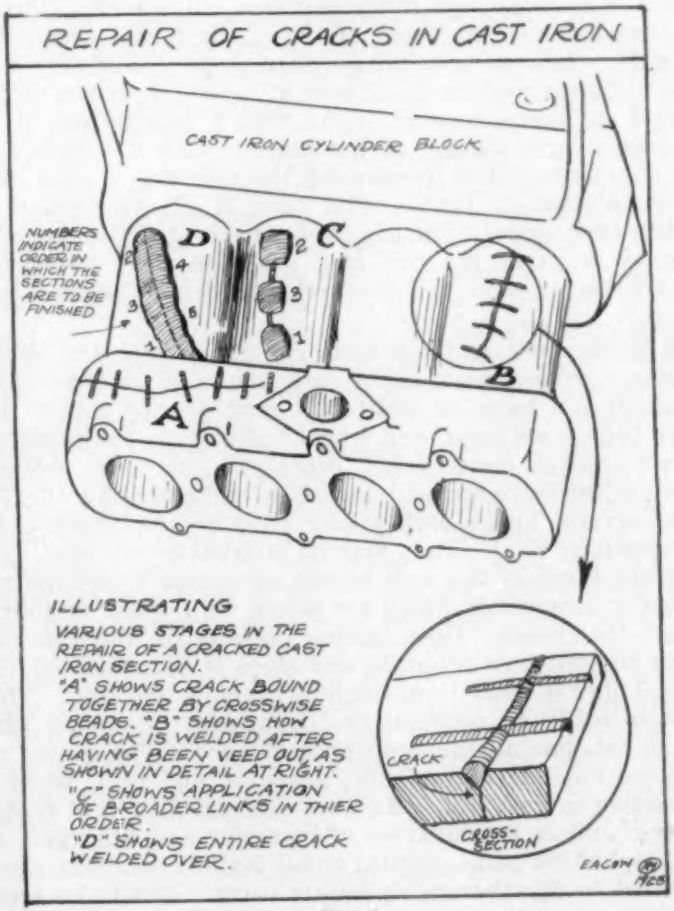
REPAIR OF CRACKS IN CAST IRON
CAST IRON CYLINDER BLOCK
NUMBERS INDICATE ORDER IN WHICH THE SECTIONS ARE TO BE FINISHED
D
C
B
A
ILLUSTRATING
VARIOUS STAGES IN THE REPAIR OF A CRACKED CAST IRON SECTION.
"A" SHOWS CRACK BOUND TOGETHER BY CROSSWISE BEADS. "B" SHOWS HOW CRACK IS WELDED AFTER HAVING BEEN VEED OUT AS SHOWN IN DETAIL AT RIGHT.
"C" SHOWS APPLICATION OF BROADER LINKS IN THIER ORDER.
"D" SHOWS ENTIRE CRACK WELDED OVER.
CRACK
CROSS-SECTION
EACON

Figure 1.

clamps that may have been applied. This is merely to insure that the operator has a good, clean surface along which to run the "V", with the confidence of a good "bite." This procedure will make the job tight in a majority of cases, especially in those of the cracked top surface of a water-jacket, or of a vertical furnace section. If the weld still lacks tightness, the operator may add metal parallel to the crosswise bead links. Great care should

be taken, however, not to concentrate the heat too long on any particular spot, else the heating strains may spread, and crack the thin cast iron outside the weld. To effect this distribution, then, the operator should proceed in some such order as that shown in the figure, taking care to fill in but 1 inch at a time, and not filling in all at one place or in one direction.

After this last welding is finished, test for strength with light taps of a hammer, and if the cast iron rings solidly, this may be accepted as sufficient proof of the strength and completeness of the weld. Yet, owing to the peculiar properties of cast iron, complete tightness may not have been attained. It is not safe to chip or weld any more, because, if the weld is chipped out, it is likely to carry a large section of the casting with it. Such a mishap may only be remedied by covering the hole with a steel plate, and welding around it. On the other hand, if a larger section of welding has been added than has been described, it is almost certain to break or crack the cast iron near the weld, because such a heavy mass of steel will contract and draw the thin cast iron with it.

All welds are essentially castings, and as such are liable to be in some degree porous, but a cast iron weld is especially prone to exhibit pin holes or leaks that may develop under pressure. Under these conditions, and where tightness is the result desired, as in a cracked water-jacket, crank-case, or boiler section, it is perfectly justifiable and satisfactory to make use of a filler. Fillers are of several kinds, each giving good results under conditions best shown by trial. They may be internal or external. Internal fillers are those of the well known gelatinous type—the radiator and boiler compounds which are mixed with water and circulated through the system. Upon leaking into the air, the solution solidifies in the pin hole or crack, and stops it permanently. A good external filler is made from sulphur, graphite and iron. This compound is really an artificial cast iron, and, if applied while the weld is hot, has all the properties of such. The excess sulphur is burned out, leaving sulphur, graphite, and iron, which is the composition of cast iron. Another external filler that is standard among plumbers is a mixture of glycerine and litharge. A good heavy asphaltum paint, applied either inside or outside, also helps, if allowed to dry thoroughly before using. It will be seen from the foregoing that there is nothing reprehensible in the use of a good filler, because it often fulfills its purpose admirably, and is not at all depended upon for strength, which the weld alone supplies.

The operator is often called upon to weld a crank case from which a huge section has been broken out and lost. In this case, a piece of steel may be cut and fitted over the hole, covering all cracks which may emanate from the broken out section. Even if the missing parts are to be had, it is far better to employ this

method than to try to fit them in, because the steel plate will make a tighter, securer job. If no external metal is allowable, a thin plate can be closely set inside, and the weld made in the gap left by the missing pieces. The latter is an excellent method to employ, because it insures the exclusion of all foreign matter from the motor or gear box, since these jobs are invariably accomplished with all bearings and parts left in place.

In closing, it may be pertinent to call attention to the fact that any of these operations are capable of being performed more quickly, and with greater ease by the use of preheating and disassembling facilities, in a shop so equipped. Nevertheless, the purpose of this article is to point out that, with a little care, all these things may be done under adverse and unfavorable conditions and with a minimum of lost time. Thus the usefulness of electric arc welding is greatly extended. It is easily possible that in a very few years this pioneer work will result in the performance with ease of welding operations that now seem possible only under the most favorable conditions.

Several years ago, for instance, it was thought absolutely impossible to weld cast iron with the electric arc so that it would be entirely machinable, yet the development of the nickel electrode has made this perfectly possible today. This electrode, however, should not be used too freely on thin sections, partially because of its cost, but more because of its high co-efficient of expansion. This of course causes its consequent great contraction which tends to increase the difficulties of thin cast iron welding more than to offset them. The small steel electrode, on the other hand, with a suitable carbon or graphite coating, refurnishes the carbon burnt out by the arc, and also allows the use of relatively small currents, say 60 to 90 amperes with a 3/32 inch electrode.

It is possible that many of the foregoing operations will seem too novel and unworkable to many readers, but the assurance is given that they are all tested by the experience of several years. It is true that they should be attempted with care, but, to the welder who is, or should be, trained in carefulness, their success is a certainty.

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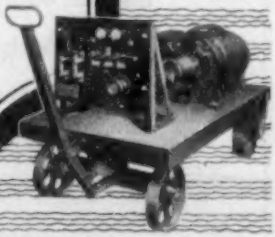

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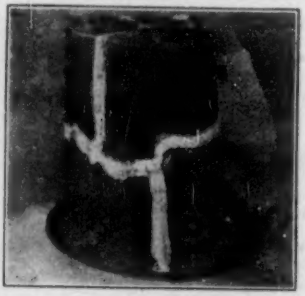

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